The 35-Day Pulse Evolution Cycle of Her X-1

by

Daniel Matthew Scott

A dissertation submitted in partial fulfillment
of the requirements for the degree of

Doctor of Philosophy

University of Washington

1993

Approved by _____

(Chairman of Supervisory Committee)

Program Authorized
to Offer Degree Department of Astronomy
Date _____

University of Washington

Abstract

The 35-Day Pulse Evolution Cycle of Her X-1

by D. Matthew Scott

The pulse shape of the X-ray pulsar Her X-1 exhibits a systematic set of changes during its well known 35-day cycle. The pulse evolution is observed during the ten day long MAIN HIGH state and the five day long SHORT HIGH state and is currently a unique phenomena among the known X-ray pulsars. The pulse shape and its evolution have been observed with an extensive set of *Ginga* observations taken over the period 1988-1991. The core of the data set consists of a MAIN-SHORT-MAIN HIGH sequence in 1989 in which the evolution of the pulse during the SHORT HIGH state has observed for the first time. The phenomenology of the pulse evolution is documented and several new details have been found. Scaled differences between pairs of pulses are used to isolate the energy or time dependent components of the pulse and to follow the pulse evolution in a quantitative fashion. The existence of similar pulse components are found in the MAIN and SHORT HIGH states and used to align the pulse profiles in phase. The astrophysical interpretation of the pulse evolution cycle is considered. Significant difficulties are found with the obervations if free precession of a neutron star with fixed beam pattern is the cause of the pulse evolution. An interpretation involving an occultation of the pulse emitting region around the neutron star by a tilted and precessing disk is favored. A large part of the observed pulse evolution of both the MAIN and SHORT HIGH state can be naturally explained with such an occultation if the beam pattern consists of a spectrally hard pencil beam and a softer fan beam that originates above the neutron star surface and is beamed in the direction antipodal to the pencil beam. The neutron star is also required to be highly inclined ($\sim 45°$) to the binary orbital axis and the radius of the inner disk must be small ($\leq 50 R_{NS}$).